

FISH FAUNA OF THE WETLANDS OF SRIHARIKOTA ISLAND, SOUTHERN INDIA AND THEIR CONSERVATION ISSUES

RANJIT MANAKADAN^{1,3}, K. REMA DEVI^{2,4}, S. SIVAKUMAR^{1,5} AND T.J. INDRA^{2,6}

¹Bombay Natural History Society, Hornbill House, Dr. Sálim Ali Chowk, S.B. Singh Road, Mumbai 400 001, Maharashtra, India.

²Zoological Survey of India, Southern Regional, Santhome High Road, Chennai, Tamil Nadu, India.

³Email: ransan5@rediffmail.com

⁴Email: remadevi_zsi@yahoo.com

⁵Email: sivaprema3sep@yahoo.com

⁶Email: jpandurangan@hotmail.com

Fish fauna in different wetlands of Sriharikota Island was assessed during February 2002 to April 2004. A total of 53 fish species belonging to 36 families and 10 orders were recorded. Nineteen species were recorded from freshwater habitats, 38 from fresh-brackish and 39 from brackish-saline wetlands. Two important perennial wetlands in the Island, Malliplate Vagu (a fresh-brackish stream) and Urugayya (a brackish-saline lake), also serve as nurseries for young of marine fish and prawn species, including two Anguillid eels. The abandoned irrigation ponds are major refuges for two threatened air-breathing species, *Clarias batrachus* and *Anabas testudineus*. An exotic species *Oreochromis mossambicus* and a species native to north India *Colisa lalia*, were also recorded. The species composition and relative abundance of fish species in the major wetlands are discussed individually. Problems facing the wetlands are siltation and invasion by the introduced cane species *Calamus rotang*. The invasive aquatic weed *Eichhornia crassipes* is also a major problem in abandoned irrigation ponds. Sriharikota due to its high security status and largely undisturbed and unpolluted habitats has the potential to be a future conservation site for the fish fauna of this region – if the *status quo* remains.

Keywords: fish fauna, Sriharikota, wetlands, conservation

INTRODUCTION

India's burgeoning human population and its largely rural makeup places huge demands on natural resources including wetlands leading to their exploitation, alteration and degradation. It is estimated that around 50,000 small and large wetlands in India are polluted to the point of being dead (Lee Foote *et al.* 1996). Thus, it is important that even areas having small, unspoiled aquatic habitats be documented and afforded protection as these could in future be important refuges for fish fauna of the regions they represent.

As part of the initiatives of the Satish Dhawan Space Centre (SDSC) to document the biodiversity of Sriharikota Island (in Andhra Pradesh and Tamil Nadu), the Bombay Natural History Society carried out an assessment of its fish fauna (Manakadan and Sivakumar 2004a). Till this study, the ichthyofauna of Sriharikota Island, which has a rich diversity of wetlands, was undocumented probably due to the high-security status of the island as a spaceport. This is in contrast to the fish fauna of Pulicat Lake (which borders the island on three sides) that has been extensively studied (Chacko *et al.* 1953; Krishnamurthy 1969; Prasad 1971; Kaliyamurthy and Janardhana Rao 1972; Prabhakara Rao 1970, 1971; Kaliyamurthy 1972, 1981; Sanjeeva Raj *et al.* 1977; Raman *et al.* 1977; Sultana *et al.* 1980; Vasanth *et al.* 1990; Rema Devi *et al.* 2004). The fish fauna of Sriharikota, namely the freshwater forms, is of additional interest as these occur in

an island ecosystem. This paper, an offshoot of the larger study, gives an account of the fish fauna occurring in the different wetland habitats of the Sriharikota Island and discusses the conservation issues facing these wetlands.

STUDY AREA

Sriharikota is a spindle-shaped island (c. 181 sq. km) situated in Nellore and Tiruvallur districts of Andhra Pradesh and Tamil Nadu respectively (Fig. 1). Besides being the satellite launching station of the Indian Space Research Organisation (ISRO), Sriharikota has one of the last remaining, largest and best-preserved tracts of coastal Tropical Dry Evergreen Forest in India. The Island is bordered to the east by the Bay of Bengal and on the west, north and south by the Pulicat Lake. The Buckingham Canal, a largely disused navigation canal of the British Era, runs along the western edge of the Island. The Island has a coastline of c. 56 km from north to south and its east to west dimensions vary from c. 9.6 km in the central part to 1 km in the southern part. The Island comprises of low ridges of sand of marine and aeolian origin, rising c. 4.5-6.0 m above msl and sloping from west to east. The water table is at a depth of c. 2 to 5 m. The rainfall is mainly from the North-east Monsoon and to a lesser degree, the South-west Monsoon, averaging c. 1,200 mm annually. The area is particularly prone to cyclones, usually in the early part of May and October, prior or during the onset of the two monsoons, December to February

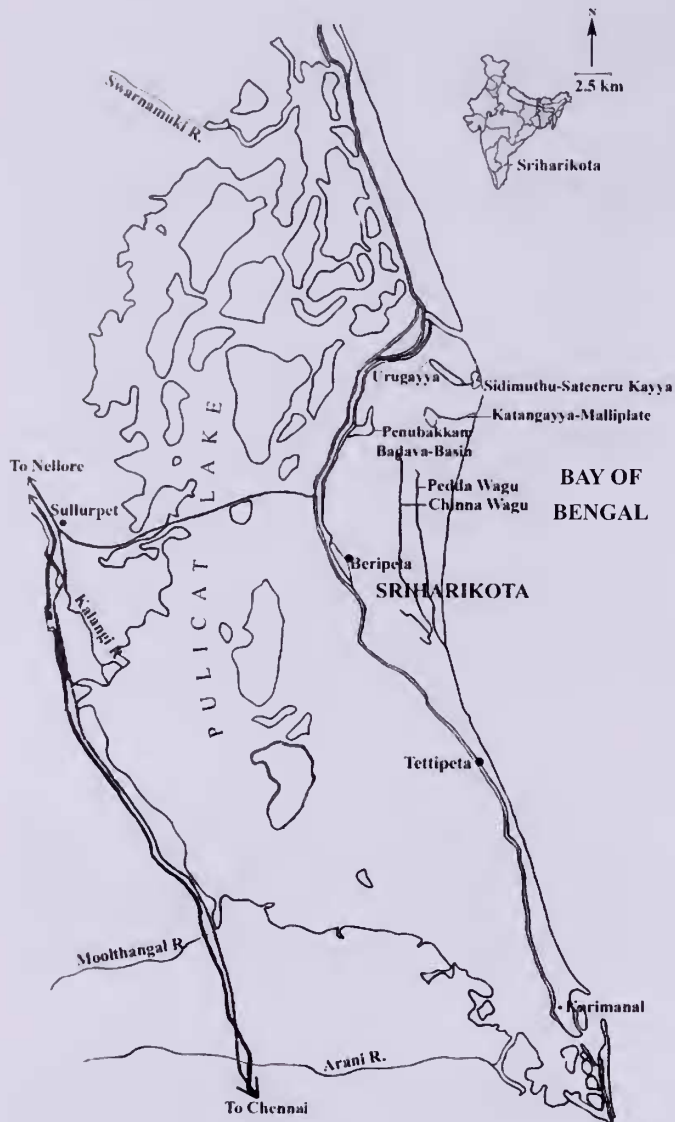


Fig. 1: Sriharikota Island and its wetlands

is the winter season with temperatures as low as 10°C, and March to September is the summer season with temperatures soaring over 40°C. Relative humidity is lowest during May (18%), and is maximum during October (99%).

METHODS

Fish sampling in Sriharikota Island was difficult due to the occurrence of a wide variety of wetlands with varying depths, turbidity, currents, presence of aquatic vegetation, debris and silt, and total or partial drying of some wetlands during summer. This was further compounded by significant microhabitat variations within habitat types. Hence, we used different sampling methods such as bank-side count, hook and line, cast-net and gill-net (Sutherland 1997; Thompson *et al.* 1998). Other methods employed to assess the ichthyofauna and to reduce the chances of missing species

for making species inventories of the different wetlands were examination of fishers' catches, interviews with fishers, recording of data during emptying of drying pools by local fishers, and visual observations over clear waters – termed as 'General Collections' in Tables 3-9.

Sampling was not carried out in two (namely, Madugu Doruvu and Madugu Vagu) of the ten major wetlands of the Island (Table 1) due to extremely difficult approach and sampling related problems, and only collections for the inventory of species were made in these two wetlands. Sampling was carried out between 0730 to 1030 hrs from February 2002 to January 2003, but collection trips, incidental sampling or observations and examination of fishermen's catches continued till April 2004. Sampling was spread out over a year to cover seasonal hydrological changes, such as water levels, salinity, drying.

Taxonomy and species names in this paper follow Talwar and Jhingran (1991) and Jayaram (1999) for freshwater and brackish water species, and Talwar and Kacker (1984) for marine species with incorporation of changes since then following Nelson (2006).

RESULTS

A total of 44 fish species were recorded in Sriharikota Island (Table 2). Additionally, fishermen reported that nine more species (denoted by # in Table 2) that occur in Pulicat lake or in wetlands on the mainland around Sullurpet or/and some islands in Pulicat lake, also occur in Sriharikota. The fish fauna of different aquatic habitats in Sriharikota Island assessed during the present study are detailed below:

Pedda and Chinna vagus: Fifteen species were recorded from the two major freshwater streams, the Pedda and Chinna vagus, consisting of 7 freshwater, 3 brackish/brackish-tolerant (*Oryzias carnaticus*, *Aplocheilus parvus* and *Oreochromis mossambicus*) and 1 fresh-brackish-marine (*Megalops cyprinoides*) species (Table 3). As sampling in the vagus was difficult due to the presence of dense aquatic vegetation, there were high possibilities of missing species. It was only during the final drying stages after the dense vegetation was removed by fishers that effective sampling was possible. However, by this time, most of the fish, especially the slower and more easily caught species, were already depleted by fishers and fish-eating birds. *Mystus vittatus*, *Colisa lalia* and *Clarias batrachus* were recorded only once in a drying pool.

Abandoned Irrigation Ponds: Twelve species were recorded in abandoned irrigation ponds (Table 4). Species such as *Anabas testudineus*, *Clarias batrachus* and *Channa* spp. were dominant in irrigation ponds. The surface

Table 1: Major wetlands of Sriharikota

Name of the wetland	Habitat Type	Approximate size/length and Maximum Depth	Aquatic Vegetation	Remarks
Pedda Vagu	Freshwater Stream	15 km; 180 cm	Dense, mostly submerged macrophytes	Seasonal, flows into the Bay of Bengal during the NE Monsoon season. Perennial at the 2 km end, which is seasonally brackish and lacks aquatic vegetation, except for reeds
Chinna Vagu	Freshwater Stream	9 km; 120 cm	Dense, mostly submerged macrophytes	Seasonal. Has no opening into the sea, but gets connected to Pedda Vagu during the peak monsoon
Abandoned Irrigation Ponds	Freshwater Pond	< 1 ha each; 150 cm	Water hyacinth <i>Eichornia crassipes</i> .	Perennial/Seasonal. Most of the ponds are now heavily silted and overgrown with cane <i>Calamus rotang</i>
Madugu Vagu	Freshwater Stream	3 km; 100 cm	Dense, mostly submerged macrophytes	Seasonal. Situated c. 2 km north of Urugayya, the Madugu Vagu, like the Urugayya, flows into the Sateneru-Sidimuthu Kayya during the NE Monsoon season
Madugu Doruvu	Freshwater Pond	c. 50 ha; 100 cm	Dense, mostly submerged macrophytes	Perennial. Situated c. 2 km south-west of Urugayya, it flows into the Sateneru-Sidimuthu Kayya during the peak monsoon season
Malliplate Vagu	Brackish water-freshwater stream	4-5 km; 180 cm	Largely absent. Upper reaches and Katangayya, have profusion of reed beds.	Comprises of a 1 sq. km headwater, the Katangayya, and the Malliplate stream; flows into the Bay of Bengal. Largely silt laden with leaf litter and debris. Perennial except for Katangayya, which dries up in summer
Penubakkam Baadava	Freshwater Pond	c. 50 ha; 100 cm	Dense, mostly submerged macrophytes	Seasonal. The P. Baadava is contiguous with the P. Basin during the peak monsoon. Dries up in summer
Penubakkam Basin	Creek with inlet/outlet into Pulicat Lake	c. 50 ha; 120 cm	Algal mats	Seasonal. Forms the lower reaches of P. Baadava, from which it receives water during the NE monsoon season. Contiguous with Pulicat lake receiving inflows during the monsoon, and during spring tides during the dry season. Dries up during other periods
Sateneru-Sidimuthu Kayya	Creek with inlet/outlet into the Bay of Bengal	c. 100 ha; 150 cm	Algal mats	Perennial, but upper reaches dry up during the post monsoon. The Sateneru-Sidimuthu Kayya receives the overflow of the Urugayya lake and Madugu Vagu during the peak NE Monsoon season. Except for the peak monsoon period, the water in the kayyas is saline, receiving inflows from the Bay of Bengal during high tides
Urugayya	Brackish water-Saline Lake	c. 100 ha; 300 cm	Algal mats	Perennial, flows into the Sateneru-Sidimuthu Kayya during the peak NE Monsoon season

feeder, *Esomus danricus*, which was rarely encountered in the other freshwater bodies, was abundant in some abandoned irrigation ponds. However, *Esomus danricus* was a common species in water bodies on the mainland as well.

Penubakkam Baadava and Penubakkam Basin: A total of 15 species were recorded in the freshwater

Penubakkam Baadava (Table 5) and 14 species in the brackish-saline Penubakkam Basin (Table 6). Fishes recorded in the Penubakkam Baadava, comprised of 10 freshwater and 5 brackish water species – the brackish water species originating from the Penubakkam Basin into which it flows at the lower reaches. Species recorded in the Penubakkam

Table 2: Checklist of the fish fauna of Sriharikota Island

Common Name	Freshwater Wetlands	Freshwater-Brackish water Wetlands*	Brackish water-Saline Wetlands**
SUBDIVISION: ELOPOMORPHA			
ORDER: ELOPIFORMES			
Family: Elopidae			
Giant Herring <i>Elops machnata</i> (Forsskal)	-	#	#
Family: Megalopidae			
Oxeye Tarpon <i>Megalops cyprinoides</i> (Broussonet)	+	+	+
ORDER: ANGULLIFORMES			
Family: Anguillidae			
Longfin Eel <i>Anguilla bengalensis</i> (Gray)	-	+	+
Shortfin Eel <i>Anguilla bicolor</i> McClelland	-	+	+
Family: Ophichthidae			
Paddy Snake-Eel <i>Pisodonophis boro</i> (Ham.-Buch.)	-	#	#
SUBDIVISION: OSTARIOCLUPEOMORPHA			
SUPERORDER: CLUPEOMORPHA			
ORDER: CLUPEIFORMES			
Family: Clupeidae			
Subfamily: Dorosomatinae			
Bloch's Gizzard-Shad <i>Nematalosa nasus</i> (Bloch)	-	-	+
SUPERORDER: OSTARIOPHYSI			
SERIES: ANOTOPHYSI			
ORDER: GONORHYNCHIFORMES			
Family: Chanidae			
Milkfish <i>Chanos chanos</i> (Forsskal)	-	#	#
SERIES: OTOPHYSI			
ORDER: CYPRINIFORMES			
Family: Cyprinidae			
Subfamily: Danioninae			
Common Flying-Barb <i>Esomus danricus</i> (Ham.-Buch.)	+	-	-
Subfamily: Cyprininae			
Spotfin Swamp Barb <i>Puntius sophore</i> (Ham.-Buch.)	+	+	-
Family: Cobitidae			
Malabar Loach <i>Lepidocephalus thermalis</i> (Val.)	+	-	-
ORDER: SILURIFORMES			
Family: Bagridae			
Long-whiskered Catfish <i>Mystus gulio</i> (Ham.-Buch.)	-	+	+
Striped Dwarf Catfish <i>Mystus vittatus</i> (Bloch)	+	-	-
Family: Clariidae			
Magur <i>Clarias batrachus</i> (Linn.)	+	-	-
Family: Heteropneustidae			
Stinging Catfish <i>Heteropneustes fossilis</i> (Bloch)	+	-	-
Family: Ariidae			
Threadfin Sea-Catfish <i>Arius arius</i> (Ham.-Buch.)	-	#	#
Family: Plotosidae			
Canine Eel-Catfish <i>Plotosus canius</i> (Ham.-Buch.)	-	#	#
SERIES: ATHERINOMORPHA			
ORDER: BELONIFORMES			
Family: Hemiramphidae			
Contaguri Halfbeak <i>Hyporhamphus limbatus</i> (Val.)	-	-	+
Family: Belonidae			
Spot-tail Garfish <i>Strongylura strongylura</i> (V. Hasselt)	-	-	+
Family: Adrianichthyidae			
Carnatic Ricefish <i>Oryzias carnaticus</i> (Jerdon)	+	+	+

Table 2: Checklist of the fish fauna of Sriharikota Island (contd.)

Common Name	Freshwater Wetlands	Freshwater-Brackish water Wetlands*	Brackish water-Saline Wetlands**
ORDER: CYPRINODONTIFORMES			
Family: Aplocheilidae			
Dwarf Panchax <i>Aplocheilus parvus</i> Raj	+	+	+
SERIES: PERCOMORPHA			
ORDER: SCORPAENIFORMES			
Family: Platycephalidae			
Bartail Flathead <i>Platycephalus indicus</i> (Linn.)	-	#	+
ORDER: PERCIFORMES			
SUBORDER: PERCOIDEI			
Family: Latidae			
Barramundi <i>Lates calcarifer</i> (Bloch)	-	+	+
Family: Ambassidae			
Commerson's Glassy Perchlet <i>Ambassis ambassis</i> Cuvier	-	+	+
Bald Glassy Perchlet <i>Ambassis gymnocephalus</i> (Lacepede)	-	-	+
Indian Glassfish <i>Parambassis ranga</i> (Ham.-Buch.)	+	-	+
Family: Terapontidae			
Target Terapon <i>Terapon jarbua</i> (Forsskal)	-	+	+
Family: Sillaginidae			
Silver Silago <i>Sillago sihama</i> (Forsskal)	-	#	#
Family: Carangidae			
Six-banded Trevally <i>Caranx sexfasciatus</i> (Quoy & Gaimard)	-	#	+
Family: Lutjanidae			
River Snapper <i>Lutjanus argentimaculatus</i> (Forsskal)	-	+	-
Family: Gerreidae			
Whiptail Silver-Biddy <i>Gerres filamentosus</i> (Cuvier)	-	#	+
Black-tipped Silver-Biddy <i>Gerres lucidus</i> Cuvier	-	#	+
Family: Scatophagidae			
Spotted Scat <i>Scatophagus argus</i> (Linn.)	-	#	#
SUBORDER: LABROIDEI			
Family: Cichlidae			
Orange Chromide <i>Etroplus maculatus</i> (Bloch)	+	+	+
Banded Pearlsplit <i>Etroplus suratensis</i> (Bloch)	-	+	+
Mozambique Tilapia <i>Oreochromis mossambicus</i> (Peters)	+	+	+
SERIES: MUGILOMORPHA			
ORDER: MUGILIFORMES			
Family: Mugilidae			
Greenback Mullet <i>Liza subviridis</i> (Val.)	-	+	+
Flathead Mullet <i>Mugil cephalus</i> (Linn.)	-	+	+
SUBORDER: GOBIOIDEI			
Family: Gobiidae			
Bighead Goby <i>Drombus globiceps</i> Hora	-	-	+
Tropical Sand Goby <i>Favonigobius reichei</i> (Bleeker)	-	-	+
Tank Goby <i>Glossogobius giuris</i> (Ham.-Buch.)	+	+	+
Sharptail Goby <i>Oligolepis acutipennis</i> (Val.)	-	+	-
Javanese Goby <i>Pseudogobius javanicus</i> (Bleeker)	-	+	+
Barred Goby <i>Pseudogobius poecilosoma</i> (Bleeker)	-	-	+
Family: Eleotrididae			
Broadhead Sleeper <i>Eleotris melanosoma</i> Bleeker	-	+	+
SUBORDER: ANABANTOIDEI			
Family: Anabantidae			
Indian Climbing Perch <i>Anabas testudineus</i> (Bloch)	+	+	-
Family: Osphronemidae			
Subfamily: Macropodinae			
Spike-tailed Paradisefish <i>Pseudosphronemus cupanus</i> (Val.)	+	+	-

Table 2: Checklist of the fish fauna of Sriharikota Island (*contd.*)

Common Name	Freshwater Wetlands	Freshwater-Brackishwater Wetlands*	Brackishwater-Saline Wetlands**
Family: Osphronemidae			
Subfamily: Luciocephalinae			
Dwarf Gouramy <i>Colisa lalia</i> (Ham.-Buch.)	+	-	-
SUBORDER: CHANNOIDEI			
Family: Channidae			
Spotted Snakehead <i>Channa punctatus</i> (Bloch)	+	+	-
Striped Snakehead <i>Channa striatus</i> (Bloch)	+	+	-
ORDER: SYNBRANCHIFORMES			
Family: Mastacembelidae			
Striped Spinyeel <i>Macrognathus pancalus</i> (Ham.-Buch.)	#	-	-
ORDER: PLEURONECTIFORMES			
Family: Soleidae			
Oriental Sole <i>Brachirus orientalis</i> (Bloch & Schn.)	-	#	#
ORDER: TETRAODONTIFORMES			
Family: Tricanthidae			
Short-nose Tripodfish <i>Triacanthus biaculeatus</i> (Bloch)	-	#	+
Family: Tetraodontidae			
Patoka Pufferfish <i>Chelonodon patoca</i> (Ham.-Buch.)	-	+	+
Species recorded	18	25	31
Additional species reported by fishermen	1	13	8
Total	19	38	39

* Freshwater stretches or/and becomes fresh during the peak monsoon; brackish water otherwise (Malliplate Vagu).

** Brackish water during the peak monsoon and turns saline as summer progresses (Urugayya).

In the case of creeks, the salinity increase is primarily due to inflows from the Bay of Bengal (Sateneru-Sidimuthu Kayya) or Pulicat Lake (Penubakkam Basin).

+ = recorded; - = not recorded; # = reported by fishermen

Basin (which borders Pulicat lake) were brackish, brackish-tolerant and marine species. The only records of *Parambassis ranga* in Sriharikota were from the Penumbakkam Baadava-Basin. Fishermen on the mainland, but not Sriharikota, were aware of this species.

Malliplate Vagu: Twenty-nine species were recorded from Malliplate Vagu (or Mavalam Vagu) comprising largely of freshwater and brackish water species (Table 7). The maximum number of gobioid species (7) were recorded from this stream. There are high possibilities of missing species in Malliplate due to the depth, debris, litter and silt along most of its course which made the sampling extremely difficult.

Urugayya: Twenty-six species were recorded from Urugayya lake (or Chola Doruvu) comprising predominantly of brackish water and marine forms (Table 8). Some freshwater groups (barbs and snakeheads) were also recorded during the peak NE Monsoon, probably originating from the nearby Madugu Doruvu, but these soon died out. *Drombus globiceps*, common in Urugayya lake, was not recorded in any other water body in Sriharikota or in Pulicat lake. Like the Malliplate Vagu, there are possibilities of missing species

in Urugayya lake also, due to its depth. Local fishers reported the occurrence of many other species in Urugayya lake, including *Elops machnata*, *Megalops cyprinoides*, *Nematalosa nasus*, *Chanos chanos*, *Caranx sexfasciatus*, *Scatophagus argus* and *Chelonodon patoca* all of which were marine and/or secondary freshwater forms.

Sateneru-Sidimuthu Kayya: Twenty species were recorded in the Sateneru-Sidimuthu Kayya (Table 9). As this waterbody, mainly serves as an outflow of the Urugayya lake (and to a lesser extent the Madugu Vagu) into the Bay of Bengal during the NE Monsoon, the species composition is similar to Urugayya, but species richness was less due to its overall shallow nature and drying over large stretches during the dry season.

DISCUSSION

The Zoological Survey of India (ZSI), which had made collections in Pulicat lake during 1963, and subsequently between 1971 to 1975, recorded a total of 88 species (Rema Devi *et al.* 2004). We recorded 22 of these 88 species in

Table 3: Fish species recorded in Pedda and Chinna vagus

Species	Rod and Line n = 6	Gill net n = 12 net	Cast net n = 4	Draining Pools n = 14	General Collections
<i>Megalops cyprinoides</i>	-	2.4 ± 5.7	-	1.9 ± 7.1	-
<i>Esomus danricus</i>	-	-	-	-	+
<i>Puntius sophore</i>	1.7 ± 2.7	0.1 ± 0.3	0.5 ± 1.0	40.9 ± 61.9	-
<i>Mystus vittatus</i>	-	-	-	5.4 ± 19.8	-
<i>Clarias batrachus</i>	-	0.1 ± 0.3	-	-	-
<i>Oryzias carmaticus</i>	-	-	-	-	+
<i>Aplocheilus parvus</i>	-	-	-	-	+
<i>Heteropneustes fossilis</i>	-	-	8.8 ± 8.5	6.6 ± 16.4	-
<i>Oreochromis mossambicus</i>	2.7 ± 3.9	12.6 ± 14.5	-	1.9 ± 5.4	-
<i>Glossogobius giuris</i>	-	-	-	0.1 ± 0.2	-
<i>Anabas testudineus</i>	-	1.3 ± 3.6	1.3 ± 0.5	8.4 ± 10.9	-
<i>Pseudosphromenus cupanus</i>	-	-	-	-	+
<i>Colisa lalia</i>	-	-	-	0.3 ± 1.2	-
<i>Channa punctatus</i>	2.5 ± 2.4	4.7 ± 6.1	4.5 ± 2.4	98.0 ± 145.5	-
<i>Channa striatus</i>	-	0.5 ± 1.2	0.3 ± 0.5	25.8 ± 77.0	-

Rod and Line: One rod and line was used on 6 days for duration of 3 hours each.

Gill-Net: One gill net was used on 12 days for duration of 2 hours each.

Cast-Net: One cast net was used on 4 days with 15 casts per trip.

Draining Pools: Denotes 14 pools drained by fishermen.

+ = incidental records during field trips, collection trips, and examination of fishermen's catches.

Values are means of catches, followed by the standard deviation.

Sriharikota Island and also recorded another 31 species not reported by the ZSI. However, comparisons between these two areas are unjustifiable as Pulicat lake is a brackish-saline ecosystem with mudflats, while Sriharikota has a variety of aquatic habitat types, including freshwater lakes and streams. However, 17 species of brackish-marine migratory fishes that were not recorded by the ZSI, including common species such as *Etroplus maculatus* and *Lates calcarifer* were encountered in the present study. There could have been possibilities of recording more and especially nocturnal species if sampling was also carried out at night.

The only endangered (CAMP 1998) freshwater fish species, occurring in Sriharikota is *Anguilla bengalensis*. Another *Anguilla* species reported to be less common in the study area by local fishers, but not evaluated by CAMP (1998), is *A. bicolor*. Species listed as vulnerable (CAMP 1998) and found in Sriharikota were *Clarias batrachus*, *Mystus vittatus* and *Anabas testudineus*. CAMP (1998) listed 329 freshwater species in India, leaving c. 300 others unassessed for their conservation status. A rare brackish water species (only half a dozen records of single individuals) of Sriharikota, which could possibly be listed as a threatened species in future assessments is *Eleotris melanosoma*. An endemic species of India, *Drombus globiceps*, originally reported from Chilika lake (Orissa) and subsequently from Ennore Estuary, Chennai (Rema Devi 1992), and Sankaraparani river, South Arcot

District, Tamil Nadu (Rema Devi *et al.* 1996), was common in Urugayya. An exotic, native to Africa, the Mozambique Tilapia *Oreochromis mossambicus* and a non-native species, Dwarf Gouramy *Colisa lalia*, earlier known only from drainages in North India but now well-established in southern India (discussed under conservation issues) were recorded from the Island.

Table 4: Fish species recorded in abandoned irrigation ponds

Species	Rod and Line n = 8	Draining Pools n = 4
<i>Esomus danricus</i>	-	+
<i>Puntius sophore</i>	-	60.0 ± 73.5
<i>Mystus vittatus</i>	0.3 ± 0.7	12.8 ± 24.8
<i>Clarias batrachus</i>	0.8 ± 1.5	7.8 ± 14.8
<i>Heteropneustes fossilis</i>	-	0.3 ± 0.5
<i>Oryzias carmaticus</i>	-	+
<i>Aplocheilus parvus</i>	-	+
<i>Oreochromis mossambicus</i>	0.9 ± 1.5	-
<i>Anabas testudineus</i>	3.0 ± 3.8	4.0 ± 7.3
<i>Pseudosphromenus cupanus</i>	-	+
<i>Channa punctatus</i>	4.1 ± 3.5	42.5 ± 33.0
<i>Channa striatus</i>	0.1 ± 0.4	-

Refer notes in Table 3

The fish species diversity was much higher in Malliplate Vagu and Urugayya than other wetlands. The Malliplate Vagu has fresh and brackish water stretches and also receives seawater inflow at the mouth's stretch that opens into the Bay of Bengal. It has high habitat diversity with dense aquatic vegetation and reeds in the sandy lake-like upper reaches known as Katangayya, and debris and silt laden marsh-like conditions with insignificant aquatic vegetation in the lower reaches. Its perennial nature (except for the Katangayya part) and seasonal connectivity to the Bay of Bengal also contribute to the high fish species diversity. Thus, the fish fauna comprised of freshwater, brackish water and marine groups such as gobies, eels, cichlids, catfish, mullets and perches, and typical freshwater groups such as barbs and murrels (snakeheads).

Urugayya is a sandy-bottom, clear water lake with a maximum depth of c. 3 m. It lacks aquatic vegetation except for algae. The fish fauna is somewhat similar to Malliplate Vagu but with hardly any freshwater species, as those that move into it during the NE Monsoon die out quickly as the salinity increases with the cessation of rains. Urugayya is reported to have dried up only twice in the last 50 years due to severe drought. When this happened, its bed was found riddled with burrows of eels, revealing its importance as a habitat for eels. There is also a fishing season for prawns in the lake just after the monsoon.

The freshwater Pedda and Chinna vagus, and the rarely visited Madugu Doruvu and Vagu, primarily support freshwater species. The Chinna Vagu dries up completely during summer; the Pedda Vagu also dries along most of its

course. Even the deeper regions dry up if the following SW Monsoon is delayed or fails, and if so, fish remain only in the perennial two kilometer fresh-brackish water stretch at its southern end. This portion gets connected periodically to the Bay of Bengal and the species composition is similar to Malliplate Vagu.

The Penubakkam Badava is a seasonal freshwater body. Freshwater fish species move into it from the Pedda and Chinna vagus and the abandoned irrigation ponds. Brackish water-marine species also move in from Pulicat lake (via the Penubakkam Basin) during the NE Monsoon. The Penubakkam Basin is an interface between Pulicat lake and Penubakkam Baadava with the fish fauna comprising of brackish water and marine species, the freshwater species dying out as soon as salinity increases during dry spells during the monsoon and post monsoon. The Penumbakkam Basin may also receive water (and fish) from Pulicat lake during the SW Monsoon if the influx of water is significant. A similar waterbody, the Beripeta Basin, was not sampled as it is more prone to drying and is more like an extension of Pulicat lake into the Island. The Sateneru-Sidimuthu Kayya is similar to Penumbakkam Basin with regard to its habitat, but the fish fauna comprises of only brackish-marine species as it opens into the Bay of Bengal. Freshwater species that may move into it during flooding die out quickly as the salinity increases.

An artificial aquatic habitat in Sriharikota is the abandoned irrigation pond. These are small deep ponds dug in the low-lying western border of the Island from Penubakkam in the north to Tettipeta in the south. The ponds were used to irrigate the paddy crop and also served as fish ponds. Many of the ponds are perennial, and the fish recruitment in ponds that dry up during summer is via the

Table 5: Fish species recorded in Penubakkam Baadava

Species	Rod and Line	Draining Pools	General Collections
<i>Puntius sophore</i>	-	42.5 ± 72.3	-
<i>Esomus danricus</i>	-	-	+
<i>Mystus vittatus</i>	-	0.8 ± 1.5	-
<i>Clarias batrachus</i>	-	1.0 ± 2.0	-
<i>Heteropneustes fossilis</i>	-	10.8 ± 9.4	-
<i>Oryzias camaticus</i>	-	-	+
<i>Aplocheilus parvus</i>	-	-	+
<i>Parambassis ranga</i>	-	-	+
<i>Etroplus maculatus</i>	0.2 ± 0.4	-	-
<i>Oreochromis mossambicus</i>	7.0 ± 8.2	7.5 ± 15.0	-
<i>Anabas testudineus</i>	0.4 ± 0.9	20.0 ± 18.3	-
<i>Pseudosphromenus cupanus</i>	-	-	+
<i>Colisa lalia</i>	-	-	+
<i>Channa punctatus</i>	0.4 ± 0.5	81.3 ± 98.7	-
<i>Channa striatus</i>	-	0.5 ± 1.0	-

Refer notes in Table 3

Table 6: Fish species recorded in Penubakkam Basin

Species	Gill-net n = 9	General Collections
<i>Nematalosa nasus</i>	8.2 ± 5.5	-
<i>Mystus gulio</i>	2.3 ± 3.8	-
<i>Hyporhamphus limbatus</i>	-	+
<i>Strongylura strongylura</i>	-	+
<i>Oryzias camaticus</i>	-	+
<i>Aplocheilus parvus</i>	-	+
<i>Parambassis ranga</i>	-	+
<i>Gerres lucidus</i>	0.9 ± 1.4	-
<i>Oreochromis mossambicus</i>	18.0 ± 13.0	-
<i>Etroplus maculatus</i>	-	+
<i>Etroplus suratensis</i>	-	+
<i>Liza subviridis</i>	13.4 ± 8.9	-
<i>Mugil cephalus</i>	1.7 ± 3.3	-
<i>Pseudogobius javanicus</i>	-	+

Refer notes in Table 3

Table 7: Fish species recorded in Malliplate Vagu

Species	Rod and Line n = 22	Gill-net n = 27	General Collections
<i>Megalops cyprinoides</i>	0.1 ± 0.3	0.3 ± 0.7	-
<i>Anguilla bengalensis</i>	0.1 ± 0.4	-	-
<i>Anguilla bicolor</i>	-	-	+
<i>Puntius sophore</i>	0.3 ± 1.3	0.2 ± 0.6	-
<i>Mystus gulio</i>	2.3 ± 2.7	1.2 ± 3.0	-
<i>Oryzias carnicus</i>	-	-	+
<i>Aplocheilus parvus</i>	-	-	+
<i>Lates calcarifer</i>	-	0.04 ± 0.2	-
<i>Ambassis ambassis</i>	1.7 ± 4.7	0.6 ± 1.2	-
<i>Terapon jarbua</i>	2.8 ± 3.1	0.7 ± 1.8	-
<i>Caranx sexfasciatus</i>	-	0.3 ± 1.0	-
<i>Lutjanus argentimaculatus</i>	-	0.04 ± 0.2	-
<i>Gerres lucidus</i>	-	0.04 ± 0.2	-
<i>Etroplus maculatus</i>	0.2 ± 0.7	-	-
<i>Etroplus suratensis</i>	1.9 ± 3.4	0.6 ± 1.4	-
<i>Oreochromis mossambicus</i>	3.4 ± 5.1	27.4 ± 22.0	-
<i>Liza subviridis</i>	-	5.6 ± 17.7	-
<i>Mugil cephalus</i>	-	5.2 ± 7.8	-
<i>Papillogobius reichei</i>	-	-	+
<i>Glossogobius giuris</i>	-	0.04 ± 0.2	-
<i>Oligolepis acutipennis</i>	-	-	+
<i>Pseudogobius javanicus</i>	-	-	+
<i>Pseudogobius poecilosoma</i>	-	-	+
<i>Eleotris melanosoma</i>	-	-	+
<i>Anabas testudineus</i>	-	1.0 ± 4.8	-
<i>Pseudosphromenus cupanus</i>	-	-	+
<i>Channa punctatus</i>	0.9 ± 3.5	0.04 ± 0.2	-
<i>Channa striatus</i>	0.6 ± 2.2	0.6 ± 2.1	-
<i>Chelonodon patoca</i>	-	-	+

Refer notes in Table 3

basin that gets connected to the other perennial irrigation ponds and other wetlands of the Island. The fish fauna of these ponds are dominated by air-breathing fishes like *Anabas testudineus*, *Clarias batrachus* and *Heteropneustes fossilis*, which can survive in murky and less oxygenated waters. Brackish water species that may move in from Pulicat lake during the peak monsoon and non-air breathing species cannot survive in the ponds as they are heavily silted and engulfed by water hyacinth and cane, resulting in low dissolved oxygen content.

CONSERVATION ISSUES

Overall, the studies revealed that Sriharikota has a variety of fairly well-protected, wetland habitats, ranging from freshwater to marine, that support a diversity of fish fauna including endangered and vulnerable species. However, there

Table 8: Fish species recorded in Urugayya

Species	Conical Prawn-net n = 8	Gill-net n = 21	General Collections
<i>Megalops cyprinoides</i>	-	0.05 ± 0.2	-
<i>Anguilla bengalensis</i>	-	-	+
<i>Anguilla bicolor</i>	0.1 ± 0.4	-	-
<i>Mystus gulio</i>	0.8 ± 1.2	0.05 ± 0.2	-
<i>Puntius sophore</i>	-	-	+
<i>Strongylura strongylura</i>	-	0.05 ± 0.2	-
<i>Oryzias carnicus</i>	-	-	+
<i>Aplocheilus parvus</i>	-	-	+
<i>Lates calcarifer</i>	-	0.05 ± 0.2	-
<i>Platycephalus indicus</i>	0.1 ± 0.4	-	-
<i>Ambassis gymnocephalus</i>	1.6 ± 2.3	-	-
<i>Terapon jarbua</i>	1.3 ± 3.5	0.2 ± 0.9	-
<i>Gerres lucidus</i>	15.5 ± 30.5	0.7 ± 1.6	-
<i>Etroplus maculatus</i>	1.4 ± 1.5	1.6 ± 1.9	-
<i>Etroplus suratensis</i>	3.5 ± 1.8	1.8 ± 1.6	-
<i>Oreochromis mossambicus</i>	1.5 ± 2.5	4.7 ± 3.1	-
<i>Liza subviridis</i>	0.5 ± 1.4	0.5 ± 2.2	-
<i>Mugil cephalus</i>	-	0.8 ± 3.1	-
<i>Glossogobius giuris</i>	0.4 ± 1.1	0.05 ± 0.2	-
<i>Drombus globiceps</i>	-	-	+
<i>Favonigobius reichei</i>	-	-	+
<i>Pseudogobius javanicus</i>	-	-	+
<i>Pseudogobius poecilosoma</i>	-	-	+
<i>Eleotris melanosoma</i>	-	-	+
<i>Channa punctatus</i>	-	-	+
<i>Triacanthus biaculeatus</i>	0.5 ± 0.9	-	-

Refer notes in Table 3

are conservation issues facing the wetlands including proliferation of invasive species, siltation and over-exploitation, which are discussed below:

Cane: Cane, *Calamus rotang* was introduced in Sriharikota in 1882-83 during the British Era (Reddy 1981). It is now seen around all freshwater habitats, engulfing the smaller ones and forming impenetrable brakes in streams obstructing the water flow. According to the tribals, cane proliferated after ISRO stopped its exploitation on takeover of the Island. To generate employment for the tribals, the SDSC started extraction of cane in 2002, but this has not made a significant impact till now, and may take a few years to witness a decline. Otherwise, cane will have to be eradicated or its spread checked to save the wetlands.

Water Hyacinth: The exotic aquatic weed, water hyacinth *Eichhornia crassipes* has almost completely covered the surface of many abandoned irrigation ponds, especially the perennial ponds in the northern areas. The mat-like

formations over the water prevent sunlight and oxygen reaching the water column and submerged plant causes oxygen depletion affecting fisheries (Naskar 1990). For this reason, the fish fauna in abandoned irrigation ponds were found to comprise primarily of hardy, air-breathing fishes. Eradication of water hyacinth in Sriharikota is not a difficult task as the ponds are small in size and the species occurs only in (some) abandoned irrigation ponds and nowhere else in the Island.

***Ipomoea carnea*:** Another South American aquatic species that is now a major weed in India is *Ipomoea carnea* (Chaudhuri *et al.* 1994). The species was also recorded in Sriharikota, but unlike some wetlands on the mainland where it is a problem, it occurs only in patches at the edges of some wetlands. One reason for this could be dominance of cane along the edges of freshwater bodies. However, the species will have to be monitored to see if it turns out to be an invasive.

Siltation: Siltation is a major problem confronting abandoned irrigation ponds, the Madugu Doruvu and Pedda and Chinna vagus. According to the locals, desilting operations used to be taken up once every few years in the irrigation ponds and deeper regions of the Pedda and Chinna vagus (which were maintained as fish ponds) prior to the takeover of the Island by ISRO. The silt collected was used in crop fields. Along with the spread of cane, some of the smaller freshwater bodies have almost disappeared with the build-up of silt. On our recommendations, the authorities of SDSC have started de-silting stretches of the Pedda and Chinna vagus, which will help restore the streams.

Table 9: Fish species recorded in Sateneru-Sidimuthu Kayya

Species	Gill-net n=8	General Collections
<i>Nematolosa nasus</i>	2.5 ± 3.1	-
<i>Mystus gulio</i>	0.3 ± 0.5	-
<i>Oryzias carnaticus</i>	-	+
<i>Aplocheilus parvus</i>	-	+
<i>Platycephalus indicus</i>	0.1 ± 0.4	-
<i>Ambassis ambassis</i>	0.4 ± 1.1	-
<i>Terapon jarbua</i>	2.4 ± 3.7	-
<i>Caranx sexfasciatus</i>	0.1 ± 0.4	-
<i>Gerres lucidus</i>	2.4 ± 3.7	-
<i>Scatophagus argus</i>	0.1 ± 0.4	-
<i>Etroplus maculatus</i>	0.8 ± 1.2	-
<i>Etroplus suratensis</i>	0.1 ± 0.4	-
<i>Oreochromis mossambicus</i>	8.9 ± 9.6	-
<i>Liza subviridus</i>	4.8 ± 4.9	-
<i>Mugil cephalus</i>	7.6 ± 6.6	-
<i>Drombus globiceps</i>	-	+
<i>Favonigobius reichei</i>	-	+
<i>Pseudogobius javanicus</i>	-	+
<i>Pseudogobius poecilosoma</i>	-	+
<i>Chelonodon patoca</i>	0.1 ± 0.4	-

Refer notes in Table 3

Exotic/Non-native fish species: Two non-native fish species now occur in Sriharikota, namely Mozambique Tilapia *Oreochromis mossambicus* and Dwarf Gouramy *Colisa lalia*. The Mozambique Tilapia, first introduced as a food fish in India in 1952 and now widespread in many parts of southern India, occurs in freshwater and brackish water habitats and also tolerates high salinity (Jones and Sarojini 1952; Editors 1954; Daniels 2006). The species is now common in Pulicat lake and Sriharikota. The impact of this hardy species on the other species is unknown as affected species may have already disappeared or declined in numbers. The Dwarf Gouramy, a popular aquarium fish, is native of northern India (Talwar and Jhingran 1991; Jayaram 1999). It is now known to occur in the wild in Chennai, a major aquarium fish breeding centre in India (Daniels 2002, 2006), c. 40 km from the southern tip of Sriharikota. It could have come to Sriharikota via the Buckingham Canal during the peak NE Monsoon or through intentional or accidental introductions in the mainland waters and islands in Pulicat lake by aquarists and fish hobbyists. The species was found to be common in two village ponds in two islands of Pulicat lake. The species was rare in Sriharikota, and the local fishermen either did not know the species or said it was a new entrant to the Island. The only other similar same-sized species that it could possibly impact in Sriharikota is *Pseudosphromenus cupanus*. The Dwarf Gouramy is a small, peaceful and harmless aquarium species (Mondadori 1977), but competition for the same food and other resources could have an impact on native species and especially *P. cupanus*.

Fishing: Fishing was one of the major occupations of the locals till ISRO took over the Island. After its takeover, ISRO gave fishing rights to some tribals to earn their livelihood by selling fish to the employees of the SDSC. Fishing is on a low scale, but there are reports that outside contractors (illegally) supply the tribals with fishing gear to catch prawns and fish species that find a good market on the mainland. The demand for fish by the locals has also increased with the development of the spaceport and facilities over the years. However, there are definite plans by ISRO to completely shift the residential areas to the mainland, which will be a boon for the fish fauna.

Other than these conservation issues, another issue apparently concerning the freshwater fish fauna is they are more prone to extinction as these inhabit an island ecosystem. However, though the island is surrounded by the brackish-saline waters of Pulicat lake and the Bay of Bengal, Sriharikota gets connected to the freshwater wetland, streams and rivers of the mainland during the peak SW Monsoon season, as almost freshwater conditions prevail in Pulicat lake during the peak NE Monsoon season. Additionally, the

cyclonic storms that lash the region once in a few years result in massive flooding, permitting even the immigration of large mammals into the Island (Kannan and Manakadan 2004; Manakadan and Sivakumar 2004b).

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